CLAIMS

What is claimed is:

1. A wavelength-tunable semiconductor laser, comprising:

a semiconductor substrate; and

at least two types of quantum well structures formed on the semiconductor substrate, each of which provides a different luminescent wavelength, wherein if the sum of a hole diffusion time plus a hole capture time is larger than the sum of an electron diffusion time plus an electron capture time, the quantum well structures are arranged in a manner that the quantum well structure located in the proximity of a P-type semiconductor side has a relatively high two-dimensional density of states, and if the sum of an electron diffusion time plus an electron capture time is larger than the sum of a hole diffusion time plus a hole capture time, the quantum well structures are arranged in a manner that the quantum well structure located in the proximity of an N-type semiconductor side has a relatively high two-dimensional density of states.

2. The wavelength-tunable semiconductor laser according to claim 1 wherein each type of the quantum well structures includes at least one quantum well.

3. The wavelength-tunable semiconductor laser according to claim 2 wherein each type of the quantum well structures is formed from different materials.

4. The wavelength-tunable semiconductor laser according to claim 3 wherein if each type of the quantum well structures is differentiated from one other in terms of different composition, a two-dimensional density of states of the quantum well structures is calculated based on the energy band structures of each constituent material of the quantum well structures, and is derived from a first quantized density of states of the quantum well structures.

5. The wavelength-tunable semiconductor laser according to claim 1 wherein each type of the quantum well structures has a different width.

6. The wavelength-tunable semiconductor laser according to claim 5 wherein if each type of the quantum well structures is differentiated from one other in terms of different width, a two-dimensional density of states of the quantum well structures is calculated based on the energy levels of the quantum well structures, and is derived from a first quantized density of states of the quantum well structures.

7. The wavelength-tunable semiconductor laser according to claim 1 wherein different luminescent wavelengths are obtained by stacking quantum well structures of different types based on the difference between the energy levels of the quantum well structures.

8. The wavelength-tunable semiconductor laser according to claim 1 wherein the following arithmetic model is used to determine which carrier is the dominant carrier:

$$\tau_{LF} = \tau_{p,diffusion} + \tau_{n,diffusion} + \tau_{cap,p} + \tau_{cap,n} = \frac{d_p^2}{4D_p} + \frac{d_n^2}{4D_n} + \frac{d_p \tau_{cp}}{W} + \frac{d_n \tau_{cn}}{W}$$

where d_p and d_n respectively represents the distance that the hole or electron diffused to the quantum well structures, D_p and D_n represent the diffusion

coefficients of semiconductor material, W represents the width of the quantum well structures, $d_p\tau_{cp}$ and $d_n\tau_{cn}$ respectively represent the electron capture time and hole capture time according to the calculation result derived based on quantum physics, and $\tau_{p,diffusion}$, $\tau_{cap,p}$, $\tau_{n,diffusion}$, and $_{cap,n}$ respectively represent the diffusion time of the holes in the separate confinement heterostructure, the diffusion time of the electrons in the separate confinement heterostructure, the equivalent hole capture time of the multi-layer quantum well structures, and the equivalent electron capture time of the multi-layer quantum well structures, and wherein an equivalent carrier capture time of the quantum well structures is be equal to the product of the carrier capture time of the multi-layer quantum well structures multiplied by a volume ratio of d_p/W or d_n/W.

9. The wavelength-tunable semiconductor laser according to claim 8 wherein if $\tau_{p,total} > \tau_{n,total}$, electrons are sufficient to enter the two-dimensional energy level of the quantum well structures earlier and thereby result in a higher electron density in the proximity of a N-type semiconductor side, and holes that enter the two-dimensional energy level of the quantum well structures later is similarly distributed according to the distribution of the electrons, so that the two-dimensional carrier distribution in the proximity of the N-type semiconductor side within the multi-layer quantum well structures is relatively high, and the quantum well structures are arranged in a manner that the quantum well structure located in the proximity of a P-type semiconductor side has a relatively high two-dimensional density of states.

10. The wavelength-tunable semiconductor laser according to claim 8 wherein if $\tau_{n,total} > \tau_{p,total}$, holes are sufficient to enter the two-dimensional energy level of the quantum well structures earlier and thereby result in a higher hole density in the proximity of a N-type semiconductor side, and electrons that enter the two-dimensional energy level of the quantum well structures later is similarly

distributed according to the distribution of the holes, so that the two-dimensional carrier distribution in the proximity of a P-type semiconductor side within the multi-layer quantum well structures is relatively high, and the quantum well structures are arranged in a manner that the quantum well structure located in the proximity of a N-type semiconductor side has a relatively high two-dimensional density of states.

11. The wavelength-tunable semiconductor laser according to claim 8 wherein the uniformity of carrier distribution within the quantum well structures is related to the two-dimensional energy density of the quantum well structures, and the carrier distribution within the quantum well structures is affected according to the determination of the dominant carrier within the quantum well structures.

12. The wavelength-tunable semiconductor laser according to claim 8 wherein the two-dimensional density of states of the quantum well structures is closely related to the width and composition of the quantum well structures, and if the quantum well structures are designed using different semiconductor materials and width specifications and occupy similar quantized energy levels, the difference between the two-dimensional energy level densities is generated from the composition of the quantum well structures, and wherein the two-dimensional density of states of the quantum well structures is influential on the uniformity of carrier distribution within the quantum well structures.

13. The wavelength-tunable semiconductor laser according to claim 1 wherein the composition of the quantum well structures is selected form III-V semiconductors used in an optical communication system.

14. The wavelength-tunable semiconductor laser according to claim 1 wherein the quantum well structures are formed from one group of II-VI semiconductors, III-V semiconductors, and IV semiconductors.

15. A method of increasing a tunable range of wavelength of a semiconductor laser by rearranging the configuration of quantum well structures of the semiconductor laser, the method comprising the steps of:

providing semiconductor laser including at least two types of quantum well structures, each type of the quantum well structures has a different luminescent wavelength; and

if the sum of a hole diffusion time plus a hole capture time is larger than the sum of an electron diffusion time plus an electron capture time, the quantum well structures are arranged in a manner that the quantum well structure located in the proximity of a P-type semiconductor side has a relatively high two-dimensional density of states, and if the sum of an electron diffusion time plus an electron capture time is larger than the sum of a hole diffusion time plus a hole capture time, the quantum well structures are arranged in a manner that the quantum well structure located in the proximity of an N-type semiconductor side has a relatively high two-dimensional density of states.

16. The method according to claim 15 wherein each type of the quantum well structures includes at least one quantum well.

17. The method according to claim 15 wherein each type of the quantum well structures is formed form different materials.

18. The method according to claim 17 wherein if each type of the quantum well structures is differentiated from one other in terms of different composition, a two-dimensional density of states of the quantum well structures is calculated based

on the energy band structures of each constituent material of the quantum well structures, and is derived from a first quantized density of states of the quantum well structures.

19. The method according to claim 15 wherein each type of the quantum well structures has a different width.

20. The method according to claim 19 wherein if each type of the quantum well structures is differentiated from one other in terms of different width, a two-dimensional density of states of the quantum well structures is calculated based on the energy levels of the quantum well structures, and is derived from a first quantized density of states of the quantum well structures.

21. The method according to claim 15 wherein different luminescent wavelength is obtained by stacking quantum well structures of different types based on the difference between the energy levels of the quantum well structures.

22. The method according to claim 15 wherein the following arithmetic model is used to determine which carrier is the dominant carrier:

$$\tau_{LF} = \tau_{p,diffusion} + \tau_{n,diffusion} + \tau_{cap,p} + \tau_{cap,n} = \frac{d_p^2}{4D_p} + \frac{d_n^2}{4D_n} + \frac{d_p \tau_{cp}}{W} + \frac{d_n \tau_{cn}}{W}$$

where d_p and d_n respectively represents the distance that the hole or electron diffused to the quantum well structures, D_p and D_n represent the diffusion coefficients of semiconductor material, W represents the width of the quantum well structures, $d_p \tau_{cp}$ and $d_n \tau_{cn}$ respectively represent the electron capture time and hole capture time according to the calculation result derived based on quantum physics, and $\tau_{p,diffusion}$, $\tau_{cap,p}$, $\tau_{n,diffusion}$, and ${}_{cap,n}$ respectively represent the diffusion time of the holes in the separate confinement heterostructure, the diffusion time of the electrons

in the separate confinement heterostructure, the equivalent hole capture time of the multi-layer quantum well structures, and the equivalent electron capture time of the multi-layer quantum well structures, and wherein an equivalent carrier capture time of the quantum well structures is be equal to the product of the carrier capture time of the multi-layer quantum well structures multiplied by a volume ratio of d_p/W or d_n/W.

23. The method according to claim 22 wherein if $\tau_{p,total} > \tau_{n,total}$, electrons are sufficient to enter the two-dimensional energy level of the quantum well structures earlier and thereby result in a higher electron density in the proximity of a N-type semiconductor side, and holes that enter the two-dimensional energy level of the quantum well structures later is similarly distributed according to the distribution of the electrons, so that the two-dimensional carrier distribution in the proximity of the N-type semiconductor side within the multi-layer quantum well structures is relatively high, and the quantum well structures are arranged in a manner that the quantum well structure located in the proximity of a P-type semiconductor side has a relatively high two-dimensional density of states.

24. The method according to claim 22 wherein if $\tau_{n,total} > \tau_{p,total}$, holes are sufficient to enter the two-dimensional energy level of the quantum well structures earlier and thereby result in a higher hole density in the proximity of a N-type semiconductor side, and electrons that enter the two-dimensional energy level of the quantum well structures later is similarly distributed according to the distribution of the holes, so that the two-dimensional carrier distribution in the proximity of a P-type semiconductor side within the multi-layer quantum well structures is relatively high, and the quantum well structures are arranged in a manner that the quantum well structure located in the proximity of a N-type semiconductor side has a relatively high two-dimensional density of states.

25. The method according to claim 22 wherein the uniformity of carrier distribution within the quantum well structures is related to the two-dimensional energy density of the quantum well structures, and the carrier distribution within the quantum well structures is affected according to the determination of the dominant carrier within the quantum well structures.

26. The method according to claim 22 wherein the two-dimensional density of states of the quantum well structures is closely related to the width and composition of the quantum well structures, and if the quantum well structures are designed using different semiconductor materials and width specifications and occupy similar quantized energy levels, the difference between the two-dimensional energy level densities is generated from the composition of the quantum well structures, and wherein the two-dimensional density of states of the quantum well structures is influential on the uniformity of carrier distribution within the quantum well structures.

27. The method according to claim 15 wherein the composition of the quantum well structures is selected form III-V semiconductors used in an optical communication system.

28. The method according to claim 15 wherein the quantum well structures are formed from one group of II-VI semiconductors, III-V semiconductors, and IV semiconductors.